Remaining Strength of Corroded Pipe Under Secondary (Biaxial) Loading Project 153J

3rd QUARTERLY PUBLIC REPORT

Period: September through December 2005

Consolidated Research and Development Program to Assess the Structural Significance of Pipeline Corrosion

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Background

Metal loss due to localized corrosion and pitting of pipelines can significantly increase the risk of rupture. Therefore, it is vitally important to accurately determine the residual strength of corroded pipelines so that proper remedial actions may be taken to avoid catastrophic events. Although historical methods and practices for inspection and integrity assessment have led to an overall safe and reliable pipeline infrastructure with a low frequency of failures, public expectations concerning pipeline safety are growing, and industry is committed to pursuing further improvements. Consequently, new US regulations and sophisticated inspection technologies have burdened many operators with large quantities of data that are often difficult to interpret and apply within the framework of existing assessment guidelines. Clearly, the industry needs a technically sound, comprehensive and integrated approach to assess and mitigate the effects of localized corrosion in gas and oil pipelines, and to assure appropriate pressure-containment safety margins.

Several methods have been developed for assessment of corrosion defects, such as ASME B31G, RSTRENG and LPC. These methods were developed using an early fracture mechanics relationship for toughness-independent failure of pressurized pipes and were empirically calibrated against a database of full-scale burst tests for thin wall pipes. Some work has already been done to address the limitations of existing assessment methods available to the industry. The objective of this project is to develop simplified guidance to assess corrosion metal loss defects in pipelines that are subjected to external loadings in service.

Summary of Progress this Quarter

Three dimensional finite element models for 48-inch diameter pipe biaxial loading tests undertaken for the Alyeska Pipeline Company (available in the public domain) in the early 1990s have been simulated to provide analytically-derived failure predictions for these tests. Actual failure pressures and bending moments have been compared with predictions and show that the prediction are in good agreement (to within 5%) with the test results.

Testing on 18 -inch diameter pipes has been initiated. Two vessel burst tests (pressure only loading) have been completed. Predicted failure pressures are in good agreement (to within 6%) with the actual burst pressures produced in the tests.

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Results

Three dimensional finite element (FE) models have been generated for a selected number of pipe Diameter/wall thickness (*D/t*) ratios. Common transmission pipe diameters, i.e., 36-in, 18-in and 8-in with (*D/t*) ratios of 72, 82 and 27, respectively, have been selected. Pipe material to API 5L grade X65 and B/X42 has been selected. These selections have been previously agreed with PRCI Materials Technical Committee members. The selection was based on providing a good range of extremes in pipe grade and pipe (*D/t*) ratio.

Following a meeting with the PRCI (Wytze Sloterdijk and David Batte) on 9 August 2005, it was agreed that selected combined loading tests undertaken for the Alyeska Pipeline Service Company in the early 1990s would be used the validate initial FE modeling and the analytical approach. The results of these tests are available in the public domain, published in proceedings of the ASME International Pipelines Conference. This dataset was considered useful in helping to validate the analytical approach used to determine the failure locus of corroded pipes under combined loading. Three tests were modeled on 48inch (*D/t* = 104) diameter grade X65 pipe. Failure predictions produced with this approach were conservative but in close agreement with results of the physical tests. Specifically, the predicted failure pressure was in agreement to within 2% of the actual failure pressure. The predicted bending moment was in agreement to within 5% for two tests and 13% for one of the tests.

A test matrix for additional validation of the FE analysis approach has been approved by the PRCI project team (Wytze Sloterdijk and David Batte). Six tests will be undertaken using pipes with an 18-inch diameter, 5.6 mm wall thickness, and Grade B/42 Pipe (*D/t*=82).

Table 1 Biaxial Loading Test Matrix

Vessel Number	**Defect Type**	**Loading**
1	80% deep axial groove	Pressure
2	80% deep axial groove	Pressure + Bending
3	80% deep circumferential groove	Pressure
4	80% deep circumferential groove	Pressure + Bending
5	80% deep patch	Pressure
6	80% deep patch	Pressure + Bending

Future Activities

Work over the next two quarters will focus on completing the biaxial loading burst tests. Additionally, the project team will be participating in an OPS sponsored Peer Review of the project on February 7, 2006.

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